Experimental Analysis of Strength of Concrete Pavement Using Flex

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***Abstract*- Researches are being conducted all over for the development of new, sustainable, high performance construction materials. Concrete pavements are widely used and preferred over bituminous pavements due to its longer life and less maintenance requirements. Advertising sheets, called flex can be used in concrete to produce a new pavement material with better performance. Flex, also called PVC banners is a jute woven fabric material used for advertisements, awareness posters, etc, which, after use becomes a non-biodegradable, reusable waste material. Incorporation of this material in concrete, to produce concrete pavement material is a step towards waste management and sustainability. Our study involves the experimental analysis of strength of concrete pavements and its future scopes using flex and a comparative strength analysis of the same with conventional concrete. The strength analysis of the concrete is done by the tests on hardened concrete, like, compressive strength test, split tensile strength test, flexural strength test, impact test, etc using the moulds casted suitably for the analysis.**

Keywords: Vinyl Banners, Conventional Concrete, Pavements

I.INTRODUCTION

The conventional concrete is found to be relatively strong in compression and, weak in tension. To increase its tension, either steel reinforcement is provided, or fibre is added. Addition of fibres can improve the tensile strength, durability and impact resistance. Flex is a widely available waste material with higher concentrations of poly-vinyl chloride. Thousands of vinyl banners are printed each day, producing large amount of harmful waste material which is not properly reused. The PVC banner when cut into smaller length, about 1cm to 1.5cm and thickness, about 0.1cm behaves like a fibre and helps to improve the concrete strength and reduce cracks. The pavement design concept is based on The Indian Road Congress. The use of flex in concrete is an effective technique to reduce waste and to improve properties of normal concrete pavement.

II.EXPERIMENTAL PROGRAM

A. *Materials Used*

The materials used in the study included Ordinary Portland Cement, fine aggregate, coarse aggregate, super plasticizer, water and flex material.

Figure 1. Materials Used

1) *Cement*

Ordinary Portland Cement of 53 grade, confirming to IS: 12269- 2013 was used and its properties were determined.

Table 1: Properties of Cement

Properties	**Values**
Specific Gravity	3.15
Properties	**Values**
Fineness	7%
Initial Setting Time	30 minutes
Final Setting Time	360minutes
Standard Consistency	32.33%
3rd Day Compressive Strength	30 N/mm²
7th Day Compressive Strength	39 N/mm²

2) *Fine Aggregate*

Crushed stone sand was used as fine aggregate and the major properties were found out.

Table 2: Properties of Fine Aggregate

Properties	**Values**
Specific Gravity	2.6
Bulk Density	1.89g/cm³
Void Ratio	0.134
Sand Type	Medium
Fineness Modulus	3.95
Porosity	0.12
Zone	I

3) *Coarse Aggregate*

Crushed stones were used as coarse aggregate and the physical properties were determined.

Table 3: Properties of Coarse Aggregate

Properties	Values
Specific Gravity	2.91
Void Ratio	0.79
Porosity	0.44
Bulk Density	1.62 g/cm³

4) *Water*

Potable water was used throughout the study for mixing.

5) *Super Plasticizer*

Master Glenium, obtained from Chalai, Trivandrum was used as super plasticizer throughout the experiment.

Table 4. Properties of Super Plasticizer

Colour	Amber
Structure	Polycarboxylic Ether Based
Density	1.082-1.142 Kg/L
Chlorine Content	< 0.1
Alkaline Content	< 3
Dosage	1%

6) *Flex*

Flex, once used for its actual purpose was cleaned and cut into a fibre form, with length 60mm and width 1mm. The flex material has a relatively higher composition of Poly-Vinyl Chloride. The flex when in the concrete, shows properties similar to that of a fibre. The flex is added in the concrete in an increasing percentage of dosage, varying as 0.25%, 0.5%, 0.75% and 1%.

Fig 2. Vinyl Banner

Table 5. Properties Of Flex

Properties	Values
Length	60mm
Diameter	0.5mm
Aspect Ratio	120

B. Mix Proportioning

The mix was proportioned for M25 grade concrete, as per IRC 44-2008. The mix proportion selected was 1:1.91:3.97 with a water cement ratio of 0.45. Table.6 shows the mix details of the M25 mix.

Table 6. Mix Details

Cement	331
Fine Aggregate	632
Coarse Aggregate	1316
Water	149
Super plasticizer	1%
w/c Ratio	0.45

C. Specimen Preparation & Curing

The concrete mix was prepared as per the mix proportion in a concrete mixer. This was done by adding the required amount of all the materials in the concrete mixer in proper order. After obtaining a uniform mix, the concrete was filled into the standard specimens in 3 layers followed by tamping for each layer using a tamping rod or a vibrator. The prepared specimens were then given an initial setting time period of 24 hours. After this period, the specimens were carefully removed from the moulds and then immersed in water to give the required curing period.

The specimens prepared included cubes of dimension 15cm×15cm×15cm, cylinders of height 30cm and diameter 15cm, beams with dimension 50cm×10cm×10cm, and discs of diameter15cm and height 5cm. A total number 105 of specimens were casted.

Fig.3 Specimens Prepared

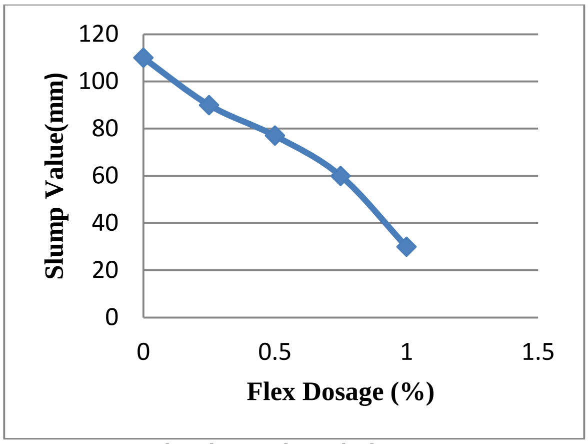
D. Tests On Fresh Concrete

The tests conducted to determine the workability on concrete were Slump Test and Compaction Factor Test. Workability of concrete gives the ease or difficulty with which the concrete is handled , transported and placed with minimum loss of homogeneity.

1) Slump Test

This is the most common method adopted for the measurement of workability of freshly prepared concrete mix. The test can be carried out both in-situ and in laboratory. Slump test is conducted with the slump cone, with top diameter 10cm, bottom diameter 20cm and height 30cm.

Fig.4 Slump Test

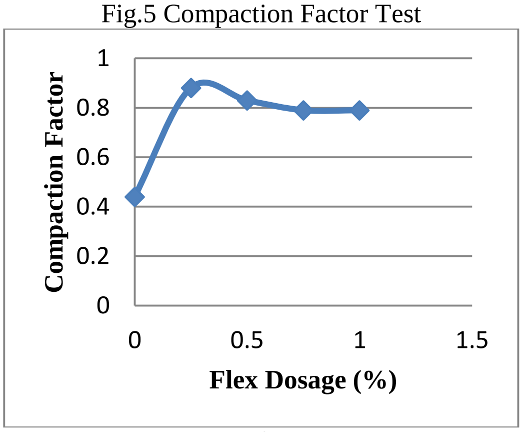


Graph.1 Slump Value with Flex Dosage

2) Compaction Factor Test

The compaction factor test is based on the principle of determining the degree of compaction achieved by standard amount of work done by allowing the concrete to fall through a standard height.

Fig.5 Compaction Factor Test



Graph.2 Variation of Compaction Factor

E. Tests On Hardened Concrete

1) *Compressive Strength Test*

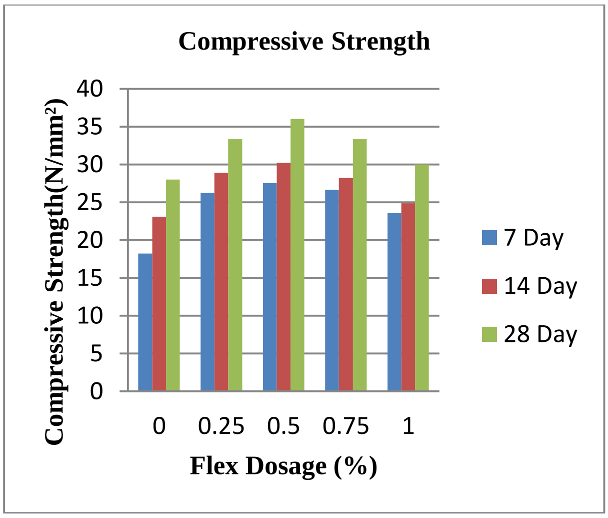
Compressive strength is one of the most important properties of concrete structures. This is done by testing the cubes prepared with dimensions 15cm×15cm×15cm, on the compressive strength testing machine. The test was conducted for conventional concrete and for various percentage addition of flex in the concrete for the strength comparison. This was done on 7th, 14th and 28th days of curing.

The concrete prepared is filled into the cube moulds and tampered properly. After 24 hours, the specimens were removed from the mould and given the required curing period, after which they were tested for compressive strength.

Fig 6. Compressive Strength Test

Table 7: Compressive Strength Observed

Percentage Of Flex	7 Day (N/mm²)	14 Day (N/mm²)	28 Day (N/mm²)
0%	18.22	23.11	28
0.25%	26.22	28.89	33.33
0.5%	27.55	30.22	36
0.75%	26.67	28.22	33.33
1%	23.56	24.89	30



Graph.3 Compressive Strength Variations

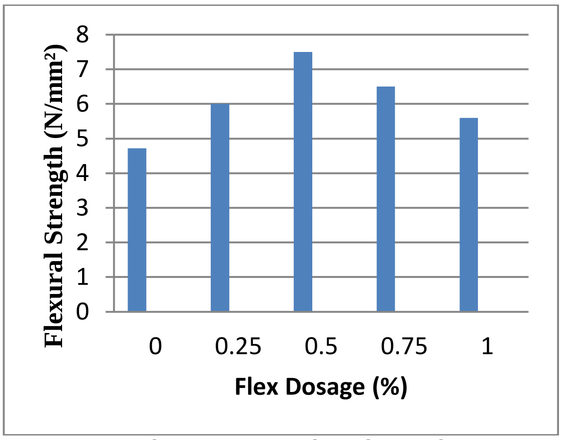
2) Flexural Strength Test

The flexural strength test on concrete evaluates the tensile strength of the concrete, indirectly. It examines the ability of the beam to withstand failure in bending. The test is carried out on standard beam specimens of size 50cm×10cm×10cm. The test is carried out after a curing period of 28 days.

Fig. 7 Flexural Strength Test

Table 8: Flexural Strength Obtained

Percentage Of Flex	Flexural Strength (N/mm²)
0%	4.72
0.25%	6
0.5%	7.5
0.75%	6.5
1%	5.6



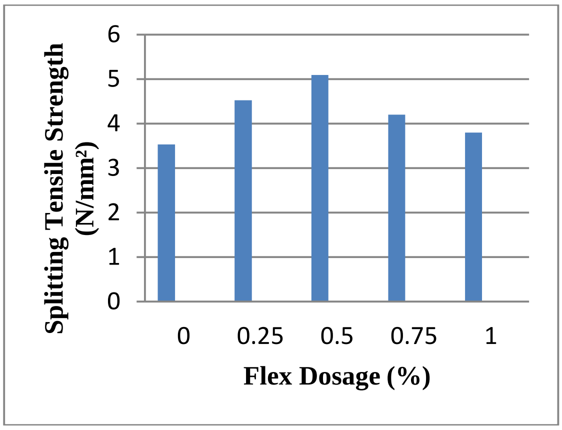
Graph.4 Variations in Flexural Strength

3) Splitting Tensile Strength Test
Splitting tensile strength is conducted on standard cylinder specimens of diameter 15cm and height 30cm. The test gives the tensile strength of the concrete. The concrete is usually weak in tension due to its brittle nature. Hence, the determination of the tensile strength of concrete is necessary to further find out the load at which cracks are formed. This method determines the strength of concrete from the cylinder that splits vertically along the diameter. Load is applied and increased continuously after placing it appropriately on the testing machine and the maximum load at failure is noted down for analysis.

Fig. 8 Splitting Tensile Strength Test

Table 9. Splitting Tensile Strength Obtained

Percentage Of Flex	Splitting Tensile Strength (N/mm²)
0%	3.53
0.25%	4.52
0.5%	5.09
0.75%	4.2
1%	3.8



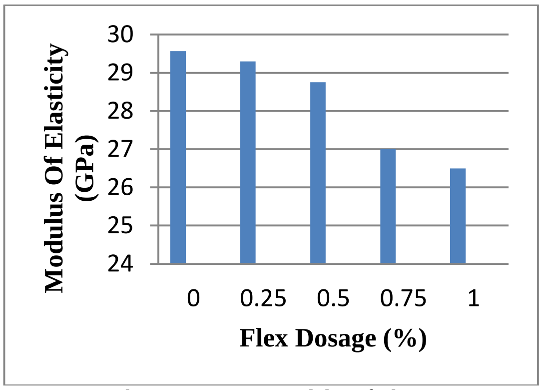
Graph.5 Variations in Splitting Tensile Strength

4) Modulus of Elasticity Test
Modulus of elasticity is a material property which describes stiffness, and hence is an important property of solid materials. This is determined by testing cube or cylinder under uniaxial compression. The modulus of elasticity is computed from the slope of the stress-strain curve plotted based on the test. Cylindrical specimens of diameter 15cm and height 30cm were used for the analysis.

Fig. 9 Modulus Of Elasticity

Table 10. Modulus Of Elasticity Calculated

Percentage Of Flex	Modulus Of Elasticity
0%	29.567 GPa
0.25%	29.3
0.5%	28.75
0.75%	27
1%	26.5



Graph.6 Variations in Modulus of Elasticity

5) Impact Resistance Test

Impact strength refers to the resistance to suddenshock or load. Cylindrical specimens of 15cm diameter and 5cm height were prepared for the test. The test was then conducted by dropping a hammer repeatedly on the steel ball, centrally placed over the specimen. The number of blows to produce a visible crack on the specimen was then recorded.


Fig. 10 Impact Resistance Test

Table 11. Impact Resistance Test

% Dosage	No. Of Blows For First Crack	No. Of Blows For Ultimate Crack	Impact Index
0%	10	12	1.2
0.25%	15	20	1.32
0.5%	18	50	2.78
0.75%	20	40	2
1%	10	25	2.5

III. CONCLUSION

The conclusions made out from the observations of the experimental observation are as follows.

- ✓ The workability of the concrete mix decreases with the incremental addition of flex. The slump values and the compacting factor observed were less than that of the conventional concrete mix.
- ✓ The strength properties of the concrete improved on flex addition.
- ✓ The optimum dosage of flex in concrete was observed to be 0.5%.
- ✓ The compressive strength of concrete increased from 28 N/mm² to 36 N /mm² on addition of flex.
- ✓ Hence, a percentage increase of 28.57 was observed in the flex added concrete.
- ✓ After the addition of flex, the flexural strength improved from 4.72 N/mm² to 7.5N/mm².
- ✓ The flexural strength improved by 58.89%.
- ✓ The splitting tensile strength of the concrete increased from 3.53 N/mm² to 5.09.
- ✓ The percentage increase in splitting tensile strength observed was about 44.19.
- ✓ The modulus of elasticity of the flex added concrete is comparatively less than that in conventional concrete.
- ✓ This shows that the flex added concrete is more rigid.
- ✓ Comparatively higher values of impact resistance were found in concrete mixes with flex than the conventional concrete.
- ✓ Besides the strength properties, the experiment provides a better alternative to dispose the reusable vinyl banners.
- ✓ The experiment is hence a move towards sustainability.

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